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Research Article

Experimental study on the effect of methanol, ethanol and butanol blends on the performance and emission of SI engine

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Abstract

Engine performance and exhaust emission have been analytically analysing for pure gasoline and gasoline blend (Methanol, Ethanol and Butanol) in a wide range of working speeds (1000–3000 RPM) without any modification of the engine systems. The experimental work conducted on the SI engine, single cylinder, four strokes, variable compression and Otto cycles. The results show that fuel consumption" increased with the rise of blend gasoline content. Exhaust pollution reduced with the increase of methanol blending ratios B20% about 90%.

Keywords: *Methanol, Ethanol and Butanol– gasoline blend; Alternative engine fuel*

1. Introduction

Alcohol fuel is one of the alternatives that used with gasoline. In this research, it has been working to improve the combustion characteristics of gasoline, which leads to improving the performance of the engine, by mixing methanol and ethanol and butanol with fuel. The addendum is considered an integral part of the fuel (Gulder LO, 1979).

One of the researchers studied the effect of mixing ethanol with gasoline, the LHV of the blended fuel decreases, while the octane number (ON) of the blended fuel increase. Practical test results in the case of mixing ethanol with gasoline increase in fuel consumption (Alvydas Pikunas et al,2003).

A study was carried to investigate the effect of adding methanol to gasoline on the performance of the internal combustion engine. Examinations were carried out, at variable speed, over the range of 1000 to 2500 rpm, and through the use of a mixture of (methanol fuel with gasoline) where it noted that the methanol mixture has a significant impact on improving the performance of SI engines. As when adding methanol to gasoline, increases the octane number (M. Abu-Zaid et al, 2004).

By adding the percentage of (0 methanol to 20 methanols) to fuel observed that has an impact on performance and exhaust emissions of the engine. It has been reduced carbon monoxide CO and HC by 25% and 10% respectively. Where it inferred when mixing ratio of M20 are most suitable for the explosive engine from the engine exhaust (Milan Pankhaniya et al, 2011).

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Influence of butanol mixture in S I engine performance and emission worked with gasoline fuel and ethanol fuel. Performance examinations obtained carried for fuel consumptions‹‹, thermal efficiency, brake power, engine, torque and brake specific fuel consumption‹‹ using gasoline and additives blends with different percentages volume of fuel at varying torque engine condition. The result showed that mixing with additives increases the brake power, volumetric and brake thermal efficiencies and fuel consumption addition of 5% butanol‹‹ and 10% ethanol‹‹ to gasoline produced the excellent outcomes for all steady parameters at all engine torque values (M.V.Mallikarjun et al, 2009).

2. Experimental Work

The engine used for the studies was a single cylinder SI engine model Prodit 4 cylinders, 4 strokes and water cooling. The engine geometrical specifications are 90 mm bore, 85 mm stroke; 541cm^3 swept volume and 4-17.5 compression ratio. Further details on the engine specifications and parameters listed in Table 1.

Table 1: Engine Specification

Engine type	4cyl., 4-stroke
Engine model	PRODIT gasoline engine rig
Combustion type	water cooled, natural aspirated
Swept volume	541cm^3
Valve per cylinder	two
Bore	90 mm
Stroke	85 mm
Compression ratio	4-17.5
Fuel injection pump	Unit pump 26 mm diameter plunger
Max power	4kW at 2800 rpm
Max Torque	28Nm at 1600 rpm

2.1 Exhaust Gas Analyzer

Exhaust emissions measurements by Gas analyzer of model 488 Italy is used to measure the exhaust emissions. The gas analyzer is connected via engine exhaust stainless steel tailpipe, which discharged emissions from the engine without any dilution into the analyzer. The gas analyzer measures CO, CO2 and UHC. The measurement technique of the gas analyzer works based on an infrared ray's energy transmitted through the flow of exhaust gases to a detector.

Fig.1 The exhaust gas analyzer type (TEXA)

2.2 Preparation of samples

Different samples were used in the study. Gasoline was taken from the IRAQ Oil Refinery Company and blend (Methanol, Ethanol and Butanol) were taken from Chemical Laboratory". The fuel was mixed with the mixture to get four test blends (B10- B20, M10 - M20 and E10-E20).The fuel blend was prepared just before begin the experiment works, to ensure that the fuel mixture is homogeneous.

3. Result and discussion

Figure 2 represents the relationship between fuel consumption with engine speed.

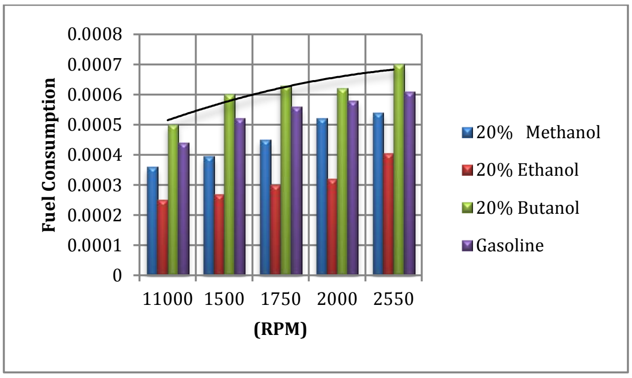

Fig.2 Specific fuel consumption versus engine speed

It was noted that by conducting experimental tests on engine performance by mixing alcohol fuel with gasoline in different volumetric percentage. The fuel consumption was less when blending gasoline with ethanol at the rate of the volumetric ratio of 20% and less when mixing gasoline with methanol. In Figure 3: The best performance of the engine (fuel consumption) when mixing fuel with ethanol, as well as fuel when mixed with methanol at 10%.

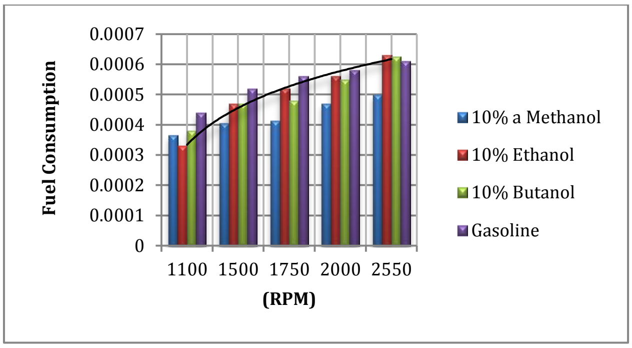

Fig.3 Specific fuel consumption versus engine speed

Figure 4 represents the relationship between carbon monoxide with engine speed. Where it was noted by conducting experimental tests on engine pollutants by mixing alcohol fuel with gasoline in different volumetric percentage. The carbon monoxide (CO) reduction when blending gasoline with ethanol at the rate of 10% by vol became less when mixing gasoline with methanol. Figure 5 shows that pollutants can be reduced by mixing gasoline with methanol at the ratio of 20% by vol.

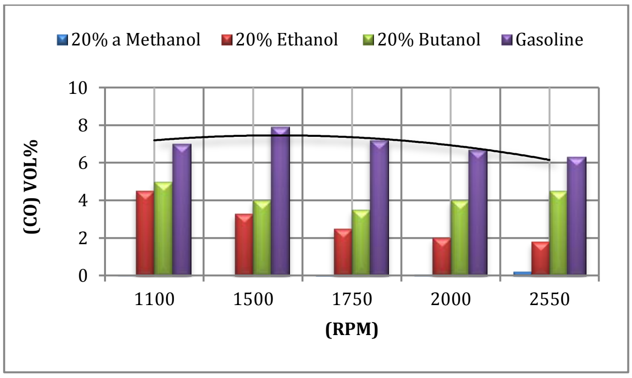

Fig.4 Carbon monoxide versus engine speed

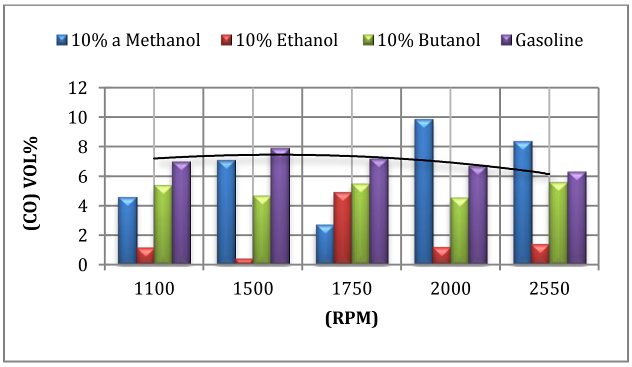

Fig.5 Carbon monoxide versus engine speed

Figure 6 represents the relationship between unburned hydrocarbon emissions (UBHC) with engine speed. As seen in fig 6, the UBHC was gradually reduced when the blend methanol ratio increased in the blend at the rate of the volumetric ratio of 20%. The (UBHC) reduction when mixing gasoline with methanol at the 10% by vol.

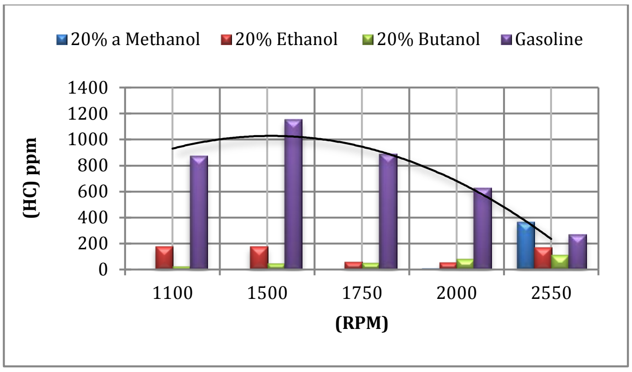

Fig.6 HC emission versus engine speed

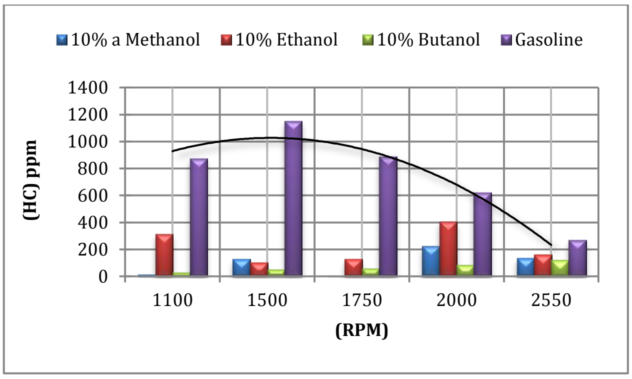

Fig.7 HC emission versus engine speed

Conclusions

1- The fuel consumption decreases with the increases in ethanol blending ratios B20%.

2- Focusing on emission, it found that CO of the spark ignition engine decreased when the gasoline blend increased. Reduced the amount of the percent of (CO) about 90% when using methanol blend M20%, butanol blends B20% =40%, and ethanol blends E20%= 60%.

3- Emission of CO decreased about 65.% when using methanol blend M10%; butanol blends B10% =926%, and ethanol blends E10%= 73%.

4- Emission of HC decreased when the gasoline blend increased. Reduced the amount of the percent of HC about 90% when using methanol blend M20%, butanol blends B20% =90%, and ethanol blends E20%= 83.4%.

5- Emission of HC decreased about 90% when using methanol blend M10%, butanol blends B10% =90%, and ethanol blends E10%= 70%.

The following equations were used in calculating engine performance parameters:

1- The brake specific fuel consumption.

$$bsfc = \frac{\dot{m}f}{bp} \times 3600 \quad kg/(kW.hr) \qquad (1)$$

2- Brake thermal efficiency is defined as in Eq.

$$\eta bth = \frac{bp}{\dot{m}f \; L.C.V} \qquad (2)$$

3- Air mass flow rate

$$\dot{m}a, act = \frac{12\sqrt{(h\_o)}}{3600} \times \rho \; air \quad kg/sec \qquad (3)$$

4- Fuel mass flow rate

$$\dot{m}f = \frac{vf \times 10^{-6}}{time} \times \rho_f \quad \text{kg/sec} \qquad (4)$$

5- Air-fuel ratio

$$A/F = \frac{\dot{m}a}{\dot{m}f} \qquad (5)$$

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Appendix (A)

Nomenclature

Symbol	Meaning	Unit
A/F	Air to fuel ratios	
Bp	Brake power	KW
bsfc	Brake Specific fuel consumption	kg/(kW.hr)

CO	Carbon monoxide	/
CO_2	Carbon dioxide	/
S.I.engine	spark ignition engine	/
HC	Unburned hydrocarbons	Ppm
Ho	Differential manometer	Cm
$\dot{m}a$	Air mass flow rate	kg/sec
$\dot{m}f$	Fuel mass flow rate	kg/sec
L.C.V	Lower calorific value	(kJ/kg)
T	Torque of engine	(N.m)
N	rotational speed	(rpm)
CR	Compression Ratio	/
M	Methanol	/
E	Ethanol	/
P	Butanol	/

Table 2 Specifications of Alcohol fuel as provided from chemistry lab and oil refinery

fuel	Chemical formula	Specific gravity (kg/dm^3)	Lower heating value(MJ/kg)	Stoichiometric air-fuel ratio(kg_{air}/ kg_{fuel})	Energy density of stoichiometric air-fuel mixture(MJ/kg	Latent heat of vaporization(at boiling point)(kJ/kg)	Octane number (RON+MON)/2
Methanol	CH_3OH	0.7913	20.08	6.43	2.750	1098	99
Ethanol	C_2H_5OH	0.7894	26.83	8.94	2.699	838	100
n-Butanol	C_4H_9OH	0.8097	32.01	11.12	2.641	584	86
Gasoline regular PON87	$CH_{1.87}$	0.7430	42.9	14.51	2.769	349	87